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Horizontal and Vertical Distribution of Sprat in the Southern Baltic Sea during Spawning Time. First Results of the 1999 German June Acoustic Survey

by
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Abstract

This paper describes the results of an acoustic survey carried out with RV ‘Walther Herwig III’ in May/June 1999 in the Baltic Sea, Sub-divisions 24-28. The survey was conducted within the framework of the EU project ‘Environmental and fisheries influence on fish stock recruitment in the Baltic Sea (STORE)’. The main objective was to describe the spatial distribution of sprat stocks and to estimate their abundance by means of acoustic methods. The horizontal and vertical distribution was analysed in relation to hydrographic conditions. The latter were characterised by a typical spring situation. Due to the spring warming of the surface layer a thermocline was observed at 15 to 20 m. The permanent halocline, which was connected to a temperature discontinuity, was located between 55 to 65 m. Both clines clearly affected the vertical distribution of sprat. In deeper basin areas where both layers occurred, sprat was mainly concentrated in a small layer below the permanent halocline. In shallow water, which was characterised by a missing permanent halocline, sprat was predominantly allocated below the thermocline. For the main investigated area in Sub-division 25 the sprat and herring stock size was estimated to be about 40.8 x 10^9 individuals or 355.5 x 10^3 t, and about 1.0 x 10^9 individuals or 41.5 x 10^3 t, respectively. As it is known that sprat is feeding on cod eggs, it is discussed that the distribution of sprat is connected to the occurrence of cod egg layers.

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1 Introduction

Herring and sprat have a central position in the Baltic Sea ecosystem. Most of the fish biomass in the Baltic Sea is constituted of these pelagic fish species. They are important prey items for i.e. cod and salmon, and heavily exploited by the fishery. At present most of the catches are taken by pelagic trawls. In the southern and central part of the Baltic Sea (Sub-divisions 25-28), the actual catches for herring and sprat reached around 446,000 t (ICES 2000/ACFM:14) in 1999. In the last years there is a trend of declining pelagic stock biomass in the Southern and Central Baltic, which is more pronounced for herring than for sprat.

Fishery independent estimates of pelagic stocks by using acoustic signals (echo sounders) have been carried out in the Baltic since the end of the 1970s. The corresponding results mainly from autumn surveys have been used for calibrating ("tuning") VPAs (Virtual Population Analyses), which are based on commercial fishery landings. In some years a hydroacoustic survey was carried out in the Southern and Central Baltic in May. The main target species was sprat since the largest fraction of the herring population during this time of the year concentrates in coastal areas for spawning, i.e. outside the area covered by the hydroacoustic surveys.

The present acoustic survey was carried out with RV 'Walther Herwig III' in May/June 1999 within the framework of the EU-funded project 'Environmental and fisheries influence on fish stock recruitment in the Baltic Sea (STORE)' in Sub-divisions 24-28. It continues the former late spring/early summer acoustic investigations.

Besides large amounts of planktonic organisms like mysiids and amphipods, sprat consumes to a large extend pelagic cod eggs (Köster 1992 and 1994). In contrast to other spawning areas of cod with salinities sufficient to keep eggs floating in the surface layer, in the Central Baltic cod eggs occur exclusively in the intermediate and bottom water, concentrating in a narrow depth range within or below the halocline (MülIer and Pommeranz 1984, Wieland 1988). Therefore they are available as prey in relatively dense aggregations for herring and sprat, which have both been identified as major predators on fish eggs (Daan 1976, Garrod and Harding 1981, Pommeranz 1981, Hopkins 1988).

In the 1980s and 1990s the Baltic cod stock biomass declined to a very low level. The total size of the cod stock was mainly influenced by the recruitment process and by the exploitation through the fishery. Investigations within the framework of the EU project 'Mechanisms influencing long term trends in reproductive success and recruitment of Baltic cod: Implications for fisheries management (CORE)' showed that the sprat predation on cod eggs is highly influenced by the hydrographic conditions. The cod eggs consumption rate is determined by the actual sprat stock size and by the overlapp of the distribution areas of cod and sprat in the water column at spawning time.

The main target of the present survey was thus to investigate the horizontal and vertical distribution of sprat in relation to the hydrographic situation in the Bornholm Basin, which is the main spawning area of sprat and cod in the Baltic Sea. In addition, results for herring, the second pelagic target species, are presented.

2 Methods

2.1 Acoustic measurements and trawling

The acoustic measurements were performed with the Simrad echosounder EK500, using a working frequency of 38 kHz. The echosounder was connected to the Bergen-Integrator BI500 for storing and analysing the echo signals. The specific settings of the hydroacoustic equipment were used as described in the ‘Manual for the Baltic International Acoustic Surveys (BIAS)’ (ICES 1999/H:1 Ref.: D: Appendix IV). The hull mounted split beam transducer ES38 was calibrated prior to this survey near the Tysnes in the Hardanger Fjord. All acoustic investigations were conducted during daytime from 4 a.m. to 6 p.m. UTC. The mean volume back scattering values (Sv) were integrated over 1 nm intervals from 8 m below the surface to the bottom. Contributions from air bubbles, bottom structures and scattering layers were removed from the echogram.

Trawling was done with the pelagic gear „PSN205“ in the midwater. The mesh size in the codend was 10 mm. The intention was to carry out at least two hauls per ICES statistical rectangle. The trawling depth and the net opening were controlled by a net-sonde. The trawl depth was chosen to catch the ‘characteristic indications’ appearing in the echogram. The trawling time lasted usually 30 minutes, but in dense concentrations the duration was reduced. The cruise track and the position of trawl hauls are shown in Figure 1. The survey covered the whole Sub-divisions 24, 25, the western part of Sub-division 26 and small areas in Sub-divisions 27 and 28. The survey covered an area of 20,818 nm^2 and the cruise track amounted to 1653 nm. 48 trawl hauls were conducted. The catch composition (kg/0.5 h trawling time) by fishery station/Sub-division is given in Tables 1-4. Sprat dominated the catches in all Sub-divisions.

Stratification and abundance estimation

For all Sub-divisions the statistical rectangles were used as strata (ICES 1999/H:1 Ref.:D: Appendix IV). The pelagic target species sprat and herring are usually distributed in mixed layers so that it is impossible to allocate the integrator readings to a specific species. Therefore the species composition was based on the trawl catch results. For each rectangle the species composition and length distribution were determined as the unweighted mean of all trawl results in this rectangle. From these distributions the mean cross section σ was calculated according to the following target strength-length (TS) relationships:

Clupeoids	TS = 20 log L (cm) - 71.2	(ICES 1983/H:12)
Gadoids	TS = 20 log L (cm) - 67.5	(Foote et al. 1986)

The total number of fish (total N) in one rectangle was estimated as the product of the mean area scattering cross section (Sa) and the rectangle area, divided by the corresponding mean cross section. The total number were separated into herring and sprat age classes according to the mean catch composition and the age readings.
The survey statistics concerning the survey area, the mean Sa, the mean scattering cross section σ, the estimated total number of fish, the percentages of herring and sprat per Sub-division/rectangle are shown in Table 5.

2.2 Hydrography

After each fishing haul a vertical CTD profile was taken with a ME-KMS3 probe in order to measure salinity and temperature. The profiles covered the entire water column down to three meters above the ground.
The CTD probe was used in combination with a water sampling device. The water samples were taken in different layers in order to identify oxygen-poor and anoxic layers. Since the highest oxygen gradient is normally found in the permanent halocline most of the samples were taken in this layer. The oxygen content was determined using the Winkler titration method. In total the oxygen content of 125 water samples from 47 hydrographic stations were analysed.

3 Results

3.1 Acoustic measurements and trawling

3.1.1 Abundance and horizontal distribution of sprat and herring

The length distribution of sprat by Sub-division is presented in Figure 2. The estimated number of sprat by age group and Sub-division/rectangle including the adult stock (age group 3+) is given in Table 6. The mean weight by age group and rectangle is shown in Table 7. The corresponding estimates of sprat biomass by Sub-division/rectangle are listed in Table 8.

The estimated total abundance of sprat was 67.0 x 10^9 specimens with a corresponding biomass of 591,6 x 10^3 t. The main part of sprat was concentrated in Sub-division 25 and the small investigated parts of Sub-divisions 26, 27 and 28.
The quantity of young sprat (age 1) was very small. The age structure shows two different patterns (Figure 3):

- East of Bornholm sprat was dominated by the age class 2 and to a lower degree by age class 3.
- In the Arkona Sea the age distribution was characterised by the uniform contribution of age class 2 to 5.

The length distribution of herring by Sub-division is presented in Figure 4. The estimated number of herring by age group and Sub-division/rectangle including the adult stock (age group 3+) is given in Table 9. The mean weight by age group and rectangle is shown in Table 10. The corresponding estimates of herring biomass by Sub-division/rectangle are summarised in Table 11.
The herring stock was estimated to be 2.4 x 10^9 individuals or about 96.9 x 10^3 t in the investigated area of Sub-divisions 24-28. Sub-division 24 was characterised by a high fraction of young herring (age groups 1-2: 62 % of the total biomass of herring), whereas Sub-division 25 was dominated by older herring (age group 3+: 83 % of the total biomass of herring).

Sprat and herring were found in the whole investigated area. Only in the southern part of Sub-division 24 and in the south-western part of Sub-division 25 herring and sprat had the same share of the total biomass (Figure 5). In all other parts of the investigated area sprat was the dominant species comprising more than 80 percent of the total biomass. The biomass of all other species including cod was negligible.

3.1.2 Vertical distribution of sprat

The Sa-values were used to show the vertical fish distribution. The factor to transfer the Sa-values into sprat biomass per rectangle are varying in Sub-divisions 25-28 only to a low extend (σ = 1.2 – 1.8). Since the amount of herring in Sub-divisions 25-28 can be regarded as negligible, the raw Sa-values are directly reflecting the sprat biomass. In Sub-division 24 the total biomass was estimated to be in about equal parts sprat and herring.

Figure 6 shows the vertical distribution of Sa-values per Sub-division. Sprat shoals occurred down to 90 m water depth in the investigated area. Sprat was not evenly distributed in the water column. In all Sub-divisions, a maximum of the Sa-values was found in water layers from 15 to 22 m depth. A second maximum was found in the Arkona Basin (Sub-division 24) in water depths of 35 to 45 m. The fish in this more shallow water was concentrated close to the bottom. A second maximum was also found in Sub-division 25 in water depths of 62 to 80 m, and in Sub-division 26 in water depths of 68 to 90 m.

The vertical distribution of sprat on a transect along 15.7° E from south to north across the Bornholm Basin is given in Figure 7. The occurrence of shoals is highly depending on the water depth of the area. In the deeper central part of the Bornholm Basin the echo traces were found from water depths of 60 to 75 m. In this area almost no echo traces were found above 60 m. Fish was mainly concentrated in layers of small shoals with a small vertical extension. At the border of the deeper part the traces raised above 60 m. In more shallow waters this layer was missing. The fish in shallow water was distributed all over the water column or concentrated in depth around 15 to 25 m.

The mean Sa-values in the water layers 8–30m, >30–60m and >60–90m depending on bottom depth as found in May/June 1999 are given per Sub-division in Figure 8.
There are no Sa-values in the water layer >60–90 m since the maximum water depth in Sub-division 24 reaches only about 60 m.
Depending on the bottom depth the contribution of the mean Sa-values in the different water layers in Sub-division 25, 26 and 28 are showing only minor differences. In shallow water areas highest clupeoid abundances were found in the 8-30 m layer, while most of the fish in deeper areas were found in the 60-90 m layer. In Sub-division 28, echo traces were only rarely found in the 60-90 m layer.
No echo traces were found in the shallow sea areas (bottom depth < 30 m) in Sub-division 27. In contrast to the results from all other Sub-divisions the highest mean Sa-values were measured in the upper water layer (8–30 m) in the deeper part of this area.

3.2 Hydrography

The thermal stratification in the investigated area was characterised by a typical spring situation with surface temperatures between 9 and 13 °C. A distinct thermocline occurred between 10 and 20 m depth, separating the winter water with temperatures of about 5 - 6 °C from the surface layer. Temperature and thickness of the warm surface layer decreased from west to east (Figure 9 and 10). The temperature further decreased from waters below the thermocline up to the permanent halocline. The temperature minimum was found mostly just above the permanent halocline.
The salinity of the surface layer ranged between 6.8 psu in the east and 7.3 psu in the west of the investigated area. The vertical distribution of the salinity was nearly homogeneous down to 35-40 m in the Arkona Basin, to 55-60 m in the Bornholm Basin and to 60-65 m in the southern Gotland Sea. The salinity increased insignificantly by 0.5 – 1.0 psu up to the permanent halocline. Below the permanent halocline temperature and salinity increased with increasing water depth. The maximum salinity was determined to be:

- 13.3 psu at 8.5 °C (water depth 46 m) in the Arkona Basin,
- 16.7 psu at 7.6 °C (water depth 89 m) in the Bornholm Basin and
- 11.6 psu at 5.7 °C (water depth 103 m) in the western Gotland Sea.

The oxygen content in the surface layer ranged from 5.3 ml/l to 8.2 ml/l. Below the halocline the oxygen content decreased rapidly with increasing salinity. In water depths of 60–70 m related to a salinity of 14 – 15 psu the oxygen content was in most cases below 2 ml/l in the Bornholm Basin (Figure 11). In this area one water sample taken in 79 m water depth contained hydrogen sulphide. On one station sampled in the south-western Gotland Sea 1 ml/l oxygen was found even in 102 m depth.

4 Discussion

4.1 Sprat

Abundance and horizontal distribution

Sprat in the Baltic is assessed as one single unit (Sub-divisions 22-32) since 1992. According to the latest assessment, the total spawning stock biomass size had a moderate level of about 500,000 to 600,000 t in the early and mid-1970s (ICES 2000/ACFM:14). It then decreased to a minimum size of about 130,000 t in 1981. Until 1984 it recovered slightly and remained on a level of about 300,000 to 400,000 t. Since 1990, sprat total spawning biomass has constantly been increasing and was on its highest level on record in 1997 with about 1,500,000 t. During the last two years the stocks size was estimated to be at a lower level of about 1,000,000 t.
The main investigated area of the hydroacoustic survey in May/June 1999 was the Bornholm Basin (Sub-division 25). The total sprat biomass in this area was estimated to be 355.5 x 10^3 t. Former investigations at the same survey time in this area resulted in far lower stock size estimates (Falk et al. 1976: 144,000-170,000 t, Linquist et al. 1977: 47,000 t, Falk et al. 1981: 150,000-167,000 t; Kästner et al. 1984: 89,700 t (age group 1+); Shvetsov et al. 1986: 83,600 t (age group 1+). The present and past biomass estimates in Sub-division 25 are in good accordance with the corresponding estimated total stock size in the Baltic.

The hydroacoustic survey was carried out in May/June in the Bornholm Basin, which is considered as the main spawning area and the main spawning time of sprat in the Baltic Sea. In May/June the sprat spawning population (age group 3+) should reach its maximum. Our results in Sub-division 25 confirm this hypothesis:

- Almost no young sprat was detected; the age group 1 was nearly totally missing. It can be assumed that the young part of the stock was outside the spawning area in the shallow water regions, which are not covered by the survey.
- The age group 3+, reflecting the spawning part of the stock, was estimated to be the largest part of the estimated total biomass (Table 8).

It was expected that only a small part of the population were young sprat at that time of the year in the investigated area. However, another reason for the nearly totally missing age group 1 could be the poor incoming year class 1998. The information from the commercial catches and the age group 0 prognosis confirm this explanation (ICES 1999/ACFM:15).

Further results showed clear differences between the eastern and western part of the investigated area with regard to the estimated population abundance, the length and age distribution. The border between these two areas was in the western part of Sub-division 25. The higher numbers per rectangle in the eastern part were caused by the higher contribution of age group 2 and 3 (eastern part: 90 % - western part 50 %) and lower contribution of age group 5+ (eastern part: nearly missing - western part: 20 %). The differences in the age composition could also be seen in different length distributions.

Vertical Distribution

The vertical distribution was in all Sub-divisions characterised by a maximum of sprat in the upper water layer. The maximum was related to the thermocline, which was caused by the spring warming. Except for Sub-division 27 this maximum occurred in shallow sea areas, which were characterised by no permanent halocline.

In Sub-divisions 24, 25 and 26 a second sprat maximum was found below the permanent halocline. In the more shallow waters of Sub-division 24 these sprat concentrations were determined in layer of about two meters near the ground. In Sub-division 25 and 26 this layer existed in the upper part of the deep water body. The depth of this layer increased in connection with the depth of the permanent halocline from west to east.

Fish concentrations below the permanent halocline were also described by Rechlin (1967). This layer, which was found during winter time in the Gotland Sea, was identified as a concentration of wintering sprat. Between day and night the shoals were vertically migrating only to a low degree. They always existed below the thermocline, which is at that time of the year the same as the permanent halocline. Sprat concentrations were not found at water temperatures below 4 °C. Kästner et al. (1984) and Shvetsov (1986), who carried out hydroacoustic surveys in May 1984 and 1986 in the central Baltic, are also describing sprat concentrations below the permanent halocline.

Depending on Sub-division the salinity varied in the lower part of high sprat concentrations between 9 psu (Sub-division 27) and 15 psu (Sub-division 24). Salinity does obviously not limit the range of vertical distribution. In the deeper water body below the permanent halocline the oxygen concentration decreased to a large extend. The vertical distribution of sprat in deeper waters was limited by low oxygen concentrations (Figure 12).

The temperature just above the permanent halocline varied in Sub-divisions 25-28 from 2.9 °C to 4.1 °C and reached 6 °C in Sub-division 24. The vertical distribution of sprat was limited by the low temperatures since almost no concentrations were found in colder water. The results of Rechlin (1967) are supporting this hypothesis. The existence of this distribution border is related to seasonal temperature fluctuations. The sprat concentrations, which were found in our survey in the deeper basins could be described as the last remains of former wintering concentrations.

In Sub-division 28 only small sprat concentrations were found below the permanent halocline. This sprat layer was even totally missing in Sub-division 27.

The results from Kästner et al. (1984) in Sub-division 27 are matching the present results, and they are in contrast to the distribution pattern in the neighbouring Sub-divisions. Similar to our results large sprat shoals were detected in the deeper basins above the permanent halocline.

Falk et al (1975), who carried out a hydroacoustic survey in the Gotland Sea in May 1974, are describing sprat shoals during day time in water depths of 20 m to 80 m. During night time the sprat was diffuse distributed in the upper water layer up to 20 m. However, in this case high concentrations of already spawned individuals, which are not typical for this time of the year, are pointing at a not typical winter and spring time situation during that survey.

Most results are showing that the vertical sprat distribution is connected to the hydrographic scenario. The occurrence of large sprat concentrations is highly influenced by the clines of salinity, temperature and oxygen. One cline or a certain combination of these clines can be related to high sprat concentrations.

In the present survey the salinity gradient in the permanent halocline was decreasing from west to east. This decreasing gradient is resulting in a less pronounced border between oxygen rich and anoxic water in the eastern parts of the investigated area.
The lowest salinity gradient in the permanent halocline was determined in Sub-division 27. In contrast to the results of all other investigated areas sprat occurred in water layers with temperatures below 4 °C. The upward vertical sprat migration can thus not only be determined by a cold water layer. The combination of high salinity and temperature gradients may have the biggest influence on the upward vertical migration of sprat.

Vertical distribution in relation to cod egg distribution

The Bornholm Basin is the main spawning area for the eastern cod stock in the Baltic Sea (Bagge et al. 1993). Caused by changes in the hydrographic situation, this basin could be regarded as the only area with successful reproduction since the mid-1980s (Plikshs 1996). The sprat stock size in this area is directly influencing the cod recruitment by cod egg predation (Köster & Schnack 1994). The cod eggs concentrate at water depths of 50 m to 70 m where also the larvae hatch (Wieland and Zuzarte 1991). There is an overlapping in distribution between cod and sprat only in this water layer.
For every rectangle in Sub-division 25 the sprat and herring biomass was calculated in relation to the area below the 50 m depth line. About 50 % (177,700 t) of the total sprat and 34 % (25,500 t) of the total herring biomass was estimated to be in this area in May/June 1999. This means that 203,200 t clupeoids were estimated as potential cod egg predators at our survey time.
During the last ten years the main spawning time of cod shifted from May/June towards summer time (Wieland et al. 1997). For this reason the actual cod egg biomass could not be estimated during our survey time in May/June 1999. At summer time most of the sprat stock already left and more herring migrated into the Bornholm Basin (Aro 1989).

4.2 Herring

Abundance and horizontal distribution

All herring in the Baltic Proper east of Bornholm (Sub-divisions 25-29 - including Gulf of Riga - and Sub-division 32) was taken as one central Baltic stock unit since 1990. The latest assessment shows a slow but steady decrease from a record high level in 1974 of about 1,630,000 t to an actual record low level in 1999 of about 387,000 t (ICES 2000/ACFM:14).
Hydroacoustic biomass estimates in Sub-division 25 reached in 1976 about 88,000 t, in 1977 about 17,000 t and in 1979 about 40,000 t - 52,000 t (Falk et al. 1976, Linquist et al. 1977, Falk et al. 1981). Compared to these results from a period of high stock size the present estimate of about 41,500 t is rather high. The present high estimate could be explained by:

- a changed distribution pattern compared to the mid-1970s,
- an overestimation of the herring component in the total clupeoid biomass, which are calculated based on the species composition in the catches by rectangle,
- an underestimation of the actual total stock size for the unit in the central Baltic.

The herring in Sub-division 24 belongs to the assessment unit of the Western Baltic spring spawner, which inhabits Division IIIa (Skagerrak and Kattegat) and Sub-divisions 22-24. The main spawning area of this stock is around the Baltic island Rügen. The major part of the stock migrates from Skagerrak and Kattegat feeding and wintering areas through the Öresund and Belts into the Baltic in the late autumn and early winter. They all enter the coastal spawning areas in March-May, the older age groups first (Krüger et al. 1976) the younger age groups and new spawners later (Biester and Hering 1977, Groth 1985). After spawning in late spring and summer the adults (age group 2+) leave the spawning grounds and migrate back trough the Belt Sea and Kattegat to the main feeding grounds in the Skagerrak (Biester 1979). In Sub-division 24 the estimated biomass of herring was similar to the results of the joint German/Danish acoustic survey in October 1999 (ICES 2000/H:2 Ref.: D). The overall biomass and the fraction on the total biomass per age group estimated during these two surveys in Sub-division 24 are listed below:

Survey	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	Age 3+	Total
May /June 99 (t)	9417	21809	4469	5408	4213	1436	3011	853	19390	**50616**
Sept./Oct. 99 (t)	20475	13449	12366	8199	2874	264	106	207	24016	**57940**
May /June 99 (% t)	**18,6**	**43,1**	**8,8**	**10,7**	**8,3**	**2,8**	**5,9**	**1,7**	**38,3**	**100,0**
Sept./Oct. 99 (% t)	**35,3**	**23,2**	**21,3**	**14,2**	**5,0**	**0,5**	**0,2**	**0,4**	**41,4**	**100,0**

Although the overall biomass estimates are very similar, major differences are caused by the age groups 1 and 2. While the sum of both age groups contributes a similar fraction to the total biomass (61,7 % and 58,6 %) , the single age contribution is showing vice versa results. The smaller fraction of 1 year old herring in May/June as compared to October could be explained by the migration pattern. Just after spawning time on the way to the feeding grounds more older herring is occurring in this area. In October the younger local part of the population is more dominating.

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Table 1 Catch composition (kg/0.5 h) per fishery station in Sub-division 24 in May/June 1999

Fish species/Station	52	54	55	56	57	58	59	60	61	62	63	Total	Mean
CLUPEA HARENGUS	30.90	9.85	15.60	3.99	13.68	36.00	86.62	1.54	25.34	47.52	9.61	**280.65**	**25.51**
GADUS MORHUA	1.38	4.18		4.16		0.40	0.63	0.24		0.54		**11.53**	**1.05**
MERLANGIUS MERLANGUS						0.19	0.67	0.30				**1.16**	**0.11**
SPRATTUS SPRATTUS	164.50	1328.60	221.80	6.76	13.70	14.80	597.60	0.46	100.32	180.35	46.80	**2675.69**	**243.24**
Total	**196.78**	**1342.63**	**237.40**	**14.91**	**27.38**	**51.39**	**685.52**	**2.54**	**125.66**	**228.41**	**56.41**	**2969.03**	**269.91**
Medusae								**114.4**				**114.4**	**10.4**

Table 2 Catch composition (kg/0.5 h) per fishery station in Sub-division 25 in May/June 1999

Fish species/Station	10	11	12*	13	14	15	16	18	19	20	21	22	23	24	25
CLUPEA HARENGUS	0.19	2.64		0.90	3.82	0.10			0.13	0.04	0.69		47.32	47.90	17.96
GADUS MORHUA				0.69	7.19				1.74				20.44	16.22	
GASTEROSTEUS ACULEATUS	+														
MERLANGIUS MERLANGUS															
PLATICHTHYS FLESUS															
RHINONEMUS CIMBRIUS														0.16	
SPRATTUS SPRATTUS	19.90	404.70	3.94	470.20	483.00	1206.40	80.90	152.98	830.55	63.60	482.70		334.20	231.82	53.90
Total	**20.09**	**407.34**	**3.94**	**471.79**	**494.01**	**1206.50**	**80.90**	**152.98**	**832.42**	**63.64**	**483.39**	**0.00**	**401.96**	**296.10**	**71.86**
Medusae															

Fish species/Station	26	34	35	36	37	38	45	47	48	49	50	51	Total	Mean
CLUPEA HARENGUS	0.45	3.76	27.56	44.34	7.9	58	27.2	33.56	3.12	61.44	33.12	4.73	**426.87**	**16.42**
GADUS MORHUA			12.48	21.16	2.8	4.78	0.96	7.5	12	34.66		0.79	**143.41**	**5.52**
GASTEROSTEUS ACULEATUS													**+**	**+**
MERLANGIUS MERLANGUS						0.44							**0.44**	**0.02**
PLATICHTHYS FLESUS						0.35							**0.35**	**0.01**
RHINONEMUS CIMBRIUS													**0.16**	**0.01**
SPRATTUS SPRATTUS	113.80	491.80	495.58	104.12	7.86	285.85	604.06	766.7	49.4	409.55	503.2	310.28	**8960.99**	**344.65**
Total	**114.25**	**495.56**	**535.62**	**169.62**	**18.56**	**349.42**	**632.22**	**807.76**	**64.52**	**505.65**	**536.32**	**315.80**	**9532.22**	**366.62**
Medusae													**0.0**	**0.0**

Table 3 Catch composition (kg/0.5 h) per fishery station in Sub-division 26 in May/June 1999

*** = net destroyed**
+ = weight <0.01 kg

Fish species/Station	2	3	4	5	6	7	Total	Mean
CLUPEA HARENGUS	3.35	5.47	0.04	17.58	0.22		**26.66**	**4.44**
GADUS MORHUA	0.38	22.97		64.08	3.15		**90.58**	**15.10**
SPRATTUS SPRATTUS	364.65	226.60	640.70	1103.10	282.56	179.90	**2797.51**	**466.25**
Total	**368.38**	**255.04**	**640.74**	**1184.76**	**285.93**	**179.90**	**2914.75**	**485.79**
Medusae							**0.0**	**0.0**

Table 4 Catch composition (kg/0.5 h) per fishery station in Sub-division 27/28 in May/June 1999

Fish species/Station/Sub-div.	1/28	8/28	9/27	17/27	Total	Mean
CLUPEA HARENGUS	1.29	1.63	12.43	2.18	**17.53**	**4.38**
GASTEROSTEUS ACULEATUS		0.21			**0.21**	**0.05**
PLATICHTHYS FLESUS		0.14			**0.14**	**0.04**
SPRATTUS SPRATTUS	170.68	45.90	102.00	57.40	**375.98**	**94.00**
Total	**171.97**	**47.88**	**114.43**	**59.58**	**393.86**	**98.47**
Medusae					**0.0**	**0.0**

Table 5 **Survey statistics R/V "Walther Herwig III" in May/June 1999**

Sub-div.	ICES Rectangle	Area (nm^2)	Sa (m^2/nm^2)	N (nm)	Ts (σ)	Total N (mil)	Herring (%)	Sprat (%)	N Herring (mil)	N Sprat (mil)
24	**38G2**	832.9	365.0	28	2.614	1163.2	53.5	45.5	622.0	529.7
24	**38G3**	865.7	400.0	107	1.843	1878.5	17.2	82.8	323.8	1554.4
24	**38G4**	1034.8	220.0	90	1.794	1268.9	14.2	85.8	180.2	1088.7
24	**39G2**	406.1	130.0	25	2.166	243.8	27.4	72.1	66.7	175.9
24	**39G3**	765.0	285.0	67	1.610	1354.0	1.3	98.7	17.1	1336.9
24	**39G4**	524.8	227.0	55	1.777	670.3	9.2	90.4	61.8	606.2
25	**37G5**	642.2	1036.0	10	1.839	3616.9	11.4	88.3	413.0	3194.8
25	**38G5**	1035.7	143.0	58	1.839	805.2	11.4	88.3	91.9	711.2
25	**38G6**	940.2	327.0	47	1.651	1861.8	7.1	92.8	131.8	1727.3
25	**39G4**	287.3	560.0	13	1.345	1196.6	0.5	99.5	6.1	1190.5
25	**39G5**	979.0	525.0	59	1.405	3658.9	1.2	98.8	42.1	3616.1
25	**39G6**	1026.0	421.0	60	1.456	2966.2	2.7	97.2	81.3	2883.7
25	**39G7**	1026.0	540.0	63	1.283	4317.4	0.1	99.9	4.7	4312.6
25	**40G4**	677.2	146.0	51	1.431	691.0	2.7	97.2	18.7	671.9
25	**40G5**	1012.9	578.0	51	1.307	4479.0	0.7	99.2	30.9	4441.8
25	**40G6**	1013.0	664.0	68	1.315	5115.1	2.6	97.4	133.5	4981.6
25	**40G7**	1013.0	340.0	59	1.183	2911.8	0.0	100.0	0.0	2911.8
25	**41G6**	764.4	991.0	41	1.332	5688.6	0.1	100.0	2.8	5685.8
25	**41G7**	1000.0	555.0	61	1.236	4488.6	0.2	99.8	7.2	4481.4
26	**39G8**	1026.0	579.0	64	1.159	5125.0	0.1	99.9	6.1	5117.8
26	**40G8**	1013.0	687.0	59	1.178	5909.3	0.1	99.9	8.3	5900.4
26	**41G8**	1000.0	366.0	58	1.191	3072.4	0.2	99.8	7.1	3065.3
27	**42G7**	986.9	699.0	60	1.312	5257.0	2.3	97.7	123.0	5134.0
28	**42G8**	945.4	243.0	44	1.322	1738.4	0.7	99.3	12.3	1726.1

Table 6 Sprat number (million) per age group and rectangle/Sub-division in May/June 1999

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	1.1	166.3	100.0	173.0	85.7	1.1	1.1	1.6	362.4	529.7
24	**38G3**	3.1	357.5	240.9	606.2	326.4	6.2	4.7	9.3	1193.8	1554.4
24	**38G4**	27.2	345.5	180.9	348.7	175.5	3.3	2.2	5.4	716.0	1088.7
24	**39G2**	0.3	49.5	30.5	62.0	32.2	0.4	0.4	0.6	126.1	175.9
24	**39G3**	1.3	332.6	211.0	506.2	273.8	4.0	2.7	5.3	1003.0	1336.9
24	**39G4**	3.0	212.2	116.4	180.6	91.5	0.6	0.6	1.2	391.0	606.2
24	**Total**	**36.0**	**1463.5**	**879.7**	**1876.8**	**985.1**	**15.6**	**11.5**	**23.5**	**3792.3**	**5291.8**
25	**37G5**	3.2	945.7	1584.6	639.0	22.4	0.0	0.0	0.0	2245.9	3194.8
25	**38G5**	0.7	210.5	352.8	142.2	5.0	0.0	0.0	0.0	500.0	711.2
25	**38G6**	0.9	614.0	810.1	293.6	8.6	0.0	0.0	0.0	1112.4	1727.3
25	**39G4**	0.0	564.3	475.0	147.6	3.6	0.0	0.0	0.0	626.2	1190.5
25	**39G5**	0.0	1587.4	1511.5	506.2	10.8	0.0	0.0	0.0	2028.6	3616.1
25	**39G6**	0.0	1196.7	1274.6	403.7	8.7	0.0	0.0	0.0	1687.0	2883.7
25	**39G7**	0.0	2471.1	1436.1	396.8	8.6	0.0	0.0	0.0	1841.5	4312.6
25	**40G4**	0.0	291.6	288.9	90.0	1.3	0.0	0.0	0.0	380.3	671.9
25	**40G5**	0.0	2747.8	1365.0	324.6	4.4	0.0	0.0	0.0	1694.0	4441.8
25	**40G6**	0.0	2811.8	1707.0	452.9	10.0	0.0	0.0	0.0	2169.8	4981.6
25	**40G7**	0.0	2096.5	678.4	133.9	2.9	0.0	0.0	0.0	815.3	2911.8
25	**41G6**	0.0	2700.7	2302.7	670.9	11.4	0.0	0.0	0.0	2985.0	5685.8
25	**41G7**	0.0	2869.7	1289.3	317.9	4.5	0.0	0.0	0.0	1611.7	4481.4
25	**Total**	**4.8**	**21107.9**	**15076.1**	**4519.4**	**102.2**	**0.0**	**0.0**	**0.0**	**19697.7**	**40810.4**
26	**39G8**	128.1	2940.5	1757.2	292.0	0.0	0.0	0.0	0.0	2049.2	5117.8
26	**40G8**	5.9	3380.9	2171.3	342.2	0.0	0.0	0.0	0.0	2513.6	5900.4
26	**41G8**	3.1	1653.6	1172.9	235.8	0.0	0.0	0.0	0.0	1408.6	3065.3
26	**Total**	**137.0**	**7975.1**	**5101.3**	**870.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5971.4**	**14083.5**
27	**42G7**	0.0	2104.9	1884.2	1098.7	46.2	0.0	0.0	0.0	3029.1	5134.0
28	**42G8**	0.0	567.9	718.1	424.6	15.5	0.0	0.0	0.0	1158.2	1726.1
24-28	**Total**	**177.8**	**33219.3**	**23659.4**	**8789.5**	**1149.1**	**15.6**	**11.5**	**23.5**	**33648.6**	**67045.8**

Table 7 Sprat mean weight (g) per age group and rectangle in May/June 1999

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+
24	**38G2**	8.1	11.3	12.3	14.0	14.3	19.7	19.7	19.7
24	**38G3**	6.3	12.3	13.7	14.8	14.7	20.6	19.7	20.2
24	**38G4**	5.9	11.0	12.6	14.3	14.6	20.5	19.7	20.1
24	**39G2**	8.1	11.7	12.9	14.4	14.5	20.3	19.7	20.1
24	**39G3**	8.1	12.1	13.4	14.7	14.6	20.8	19.7	20.4
24	**39G4**	7.1	11.0	11.7	13.3	13.8	20.5	19.7	20.1
25	**37G5**		9.7	12.2	13.0	13.3			
25	**38G5**		9.7	12.2	13.0	13.3			
25	**38G6**		8.7	11.7	12.7	13.3			
25	**39G4**		7.2	10.9	12.1	13.3			
25	**39G5**		7.2	11.2	12.5	13.3			
25	**39G6**		7.7	11.1	12.3	13.3			
25	**39G7**		5.8	10.6	11.9	13.3			
25	**40G4**		7.9	10.8	12.0	13.3			
25	**40G5**		5.7	10.1	11.4	13.3			
25	**40G6**		5.7	10.7	12.5	13.3			
25	**40G7**		5.0	9.8	11.5	13.3			
25	**41G6**		6.9	10.6	11.7	13.3			
25	**41G7**		5.6	10.3	12.0	13.3			
26	**39G8**	5.0	6.6	8.2	9.3				
26	**40G8**	5.0	6.8	8.1	9.6				
26	**41G8**	5.0	6.9	8.3	9.6				
27	**42G7**		7.3	9.4	10.1	14.1			
28	**42G8**		7.8	9.4	10.1	13.1			

Table 8 **Sprat total biomass (t) per age group and rectangle/Sub-division in May/June 1999**

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	8.6	1878.9	1229.8	2421.8	1225.5	20.8	20.8	31.3	4950.1	6837.6
24	**38G3**	19.6	4397.5	3300.8	8972.2	4798.5	128.1	91.9	188.4	17479.9	21897.0
24	**38G4**	160.7	3800.1	2279.4	4986.9	2561.7	67.0	42.9	109.5	10047.4	14008.2
24	**39G2**	2.1	578.8	391.6	889.8	465.7	8.9	6.9	12.3	1775.3	2356.2
24	**39G3**	10.8	4024.0	2827.7	7441.0	3997.4	83.3	52.6	109.0	14511.1	18545.9
24	**39G4**	21.5	2333.8	1361.7	2402.6	1263.2	12.4	11.9	24.4	5076.2	7431.5
24	**Total**	**223.4**	**17013.2**	**11391.1**	**27114.2**	**14312.0**	**320.6**	**227.1**	**474.9**	**53839.9**	**71076.5**
25	**37G5**	0.0	9172.9	19332.3	8306.4	297.4	0.0	0.0	0.0	27936.1	37109.0
25	**38G5**	0.0	2042.0	4303.6	1849.1	66.2	0.0	0.0	0.0	6218.9	8260.9
25	**38G6**	0.0	5342.2	9437.6	3714.5	114.9	0.0	0.0	0.0	13267.0	18609.2
25	**39G4**	0.0	4062.8	5177.4	1786.2	47.5	0.0	0.0	0.0	7011.0	11073.8
25	**39G5**	0.0	11429.6	16928.9	6328.1	144.3	0.0	0.0	0.0	23401.3	34830.9
25	**39G6**	0.0	9214.9	14148.1	4965.8	115.1	0.0	0.0	0.0	19228.9	28443.8
25	**39G7**	0.0	14332.6	15222.8	4721.5	114.7	0.0	0.0	0.0	20059.0	34391.6
25	**40G4**	0.0	2303.6	3120.2	1080.4	17.9	0.0	0.0	0.0	4218.5	6522.1
25	**40G5**	0.0	15662.4	13786.5	3700.2	59.1	0.0	0.0	0.0	17545.8	33208.2
25	**40G6**	0.0	16027.3	18264.8	5660.9	132.4	0.0	0.0	0.0	24058.1	40085.5
25	**40G7**	0.0	10482.4	6648.8	1540.3	38.7	0.0	0.0	0.0	8227.8	18710.3
25	**41G6**	0.0	18635.1	24409.0	7849.8	151.2	0.0	0.0	0.0	32410.0	51045.1
25	**41G7**	0.0	16070.3	13280.3	3814.3	59.5	0.0	0.0	0.0	17154.2	33224.5
25	**Total**	**0.0**	**134778.1**	**164060.2**	**55317.5**	**1359.0**	**0.0**	**0.0**	**0.0**	**220736.6**	**355514.7**
26	**39G8**	640.4	19407.6	14408.7	2715.6	0.0	0.0	0.0	0.0	17124.3	37172.3
26	**40G8**	29.5	22990.3	17587.9	3285.3	0.0	0.0	0.0	0.0	20873.2	43893.0
26	**41G8**	15.3	11410.0	9734.7	2263.6	0.0	0.0	0.0	0.0	11998.3	23423.7
26	**Total**	**685.2**	**53807.9**	**41731.2**	**8264.6**	**0.0**	**0.0**	**0.0**	**0.0**	**49995.8**	**104488.9**
27	**42G7**	0.0	15366.1	17711.4	11096.7	651.5	0.0	0.0	0.0	29459.5	44825.7
28	**42G8**	0.0	4429.5	6749.7	4288.6	203.5	0.0	0.0	0.0	11241.8	15671.3
24-28	**Total**	**908.5**	**225394.8**	**241643.5**	**106081.6**	**16526.0**	**320.6**	**227.1**	**474.9**	**365273.7**	**591577.1**

Table 9 **Herring number (million) per age group and retangle/Sub-division in May/June 1999**

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	38G2	201.9	282.1	28.0	43.5	27.3	9.3	22.4	7.5	137.9	622.0
24	38G3	118.9	129.5	23.0	29.1	18.1	3.6	1.3	0.3	75.5	323.8
24	38G4	17.9	96.9	23.3	20.4	17.0	3.2	1.4	0.2	65.5	180.2
24	39G2	18.7	31.1	4.9	5.7	3.9	0.9	1.2	0.4	17.0	66.7
24	39G3	4.0	8.1	1.7	1.7	1.3	0.2	0.0	0.0	4.9	17.1
24	39G4	13.8	27.0	5.4	7.9	4.6	1.8	1.2	0.2	21.1	61.8
24	**Total**	**375.1**	**574.7**	**86.2**	**108.3**	**72.3**	**19.0**	**27.5**	**8.6**	**321.8**	**1271.5**
25	37G5	9.9	64.0	32.2	101.6	127.2	40.1	26.4	11.6	339.1	413.0
25	38G5	2.2	14.3	7.2	22.6	28.3	8.9	5.9	2.6	75.5	91.9
25	38G6	5.2	24.8	9.2	31.1	37.9	11.2	9.0	3.5	101.8	131.8
25	39G4	0.8	2.1	0.3	1.3	1.3	0.2	0.1	0.0	3.2	6.1
25	39G5	0.7	7.5	3.4	11.7	13.3	2.8	1.9	0.8	33.9	42.1
25	39G6	4.5	17.9	5.0	18.3	21.7	5.9	5.8	2.0	58.9	81.3
25	39G7	0.1	0.9	0.4	1.2	1.4	0.3	0.4	0.1	3.8	4.7
25	40G4	1.7	4.6	1.3	4.4	4.9	1.0	0.6	0.2	12.3	18.7
25	40G5	1.1	5.8	2.1	7.8	9.3	2.4	1.7	0.7	24.0	30.9
25	40G6	36.5	54.4	3.3	19.5	17.5	1.3	0.7	0.3	42.5	133.5
25	40G7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	41G6	0.1	0.6	0.3	0.9	0.8	0.1	0.0	0.0	2.1	2.8
25	41G7	0.1	2.5	0.6	2.0	1.7	0.2	0.1	0.0	4.6	7.2
25	**Total**	**63.0**	**199.4**	**65.3**	**222.4**	**265.3**	**74.3**	**52.6**	**21.8**	**701.7**	**964.1**
26	39G8	0.0	0.8	0.4	1.7	2.0	0.6	0.4	0.2	5.4	6.1
26	40G8	0.0	1.5	1.1	2.3	2.8	0.3	0.2	0.1	6.7	8.3
26	41G8	0.0	1.9	0.2	2.2	2.3	0.3	0.1	0.1	5.2	7.1
26	**Total**	**0.0**	**4.2**	**1.7**	**6.2**	**7.1**	**1.2**	**0.6**	**0.4**	**17.3**	**21.5**
27	42G7	0.0	8.2	4.9	18.6	66.6	18.2	5.5	1.0	114.8	123.0
28	42G8	0.0	3.4	0.8	2.6	4.5	0.7	0.2	0.2	8.9	12.3
24-28	**Total**	**438.1**	**789.9**	**158.9**	**358.0**	**415.7**	**113.5**	**86.4**	**31.9**	**1164.5**	**2392.5**

Table 10 **Herring mean weight (g) per age group and rectangle in May/June 1999**

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+
24	38G2	26.7	36.3	50.2	43.4	56.6	76.2	112.7	95.8
24	38G3	22.5	37.1	53.0	51.3	60.0	75.3	92.7	175.0
24	38G4	26.7	43.1	52.5	58.1	58.4	75.8	95.6	94.8
24	39G2	25.2	38.2	51.1	48.6	56.8	74.3	99.8	102.9
24	39G3	23.6	40.1	52.0	53.7	57.0	72.3	86.8	110.0
24	39G4	22.5	39.9	53.3	60.0	63.1	74.3	96.1	98.1
25	37G5	18.2	34.0	43.0	42.7	47.8	63.0	71.5	73.9
25	38G5	18.2	34.0	43.0	42.7	47.8	63.0	71.5	73.9
25	38G6	18.4	32.1	42.3	41.2	46.5	66.1	75.7	77.2
25	39G4	16.6	22.8	40.9	39.2	40.2	54.9	54.9	56.7
25	39G5	18.8	34.3	42.0	41.6	44.7	60.4	69.6	79.7
25	39G6	18.6	30.1	41.5	39.7	45.1	69.1	79.8	80.5
25	39G7	19.8	34.4	43.3	40.7	46.8	65.8	71.7	74.4
25	40G4	17.0	27.2	42.0	40.6	43.8	58.5	67.4	72.7
25	40G5	16.9	30.9	42.2	41.2	47.2	62.1	70.6	70.9
25	40G6	16.8	22.5	38.9	34.3	36.4	57.8	61.0	65.0
25	40G7								
25	41G6	20.7	32.2	40.9	38.5	38.3	51.3	49.8	
25	41G7	17.8	29.7	40.1	35.2	37.2	51.1	65.1	96.7
26	39G8	21.0	38.1	41.2	41.9	46.5	62.5	77.5	83.0
26	40G8	22.0	34.9	37.6	37.7	39.3	60.8	78.1	85.0
26	41G8		29.3	35.0	32.5	35.4	57.8	57.8	57.8
27	42G7		20.8	22.0	25.7	29.3	35.5	41.3	45.4
28	42G8		17.6	21.9	21.6	25.9	40.2	41.2	97.5

Table 11 **Herring total biomass (t) per age group and rectangle/Sub-division in May/June 1999**

Sub-div.	ICES Rectangle	Age groups 1	2	3	4	5	6	7	8+	3+	Sum
24	**38G2**	5391.6	10239.7	1403.6	1887.6	1547.4	710.2	2520.9	714.3	8783.9	24415.2
24	**38G3**	2674.2	4805.9	1218.6	1495.2	1088.1	268.2	120.1	56.7	4247.0	11727.0
24	**38G4**	476.7	4174.4	1221.5	1184.1	990.1	246.1	137.9	17.1	3796.8	8448.0
24	**39G2**	469.7	1186.2	248.8	275.3	223.5	64.4	119.8	44.6	976.4	2632.4
24	**39G3**	94.7	326.6	89.7	91.7	72.0	13.6	0.0	1.9	268.9	690.2
24	**39G4**	309.8	1076.5	286.3	474.1	292.2	133.0	112.7	18.2	1316.5	2702.7
24	**Total**	**9416.8**	**21809.3**	**4468.5**	**5408.1**	**4213.4**	**1435.5**	**3011.4**	**852.7**	**19389.6**	**50615.6**
25	**37G5**	180.4	2176.8	1385.4	4338.7	6081.0	2524.1	1890.1	854.4	17073.7	19430.9
25	**38G5**	40.2	484.6	308.4	965.8	1353.7	561.9	420.8	190.2	3800.8	4325.5
25	**38G6**	95.8	793.8	389.6	1281.0	1759.4	739.7	677.7	269.5	5117.0	6006.6
25	**39G4**	13.7	48.5	11.2	52.4	51.3	9.1	4.4	1.0	129.5	191.6
25	**39G5**	13.4	256.9	143.1	484.9	596.2	167.7	134.7	60.4	1587.0	1857.4
25	**39G6**	83.1	540.1	208.9	728.5	977.7	409.6	466.5	163.4	2954.5	3577.6
25	**39G7**	1.3	30.2	15.8	48.9	66.7	21.9	26.6	8.1	188.0	219.5
25	**40G4**	29.2	125.3	53.3	177.3	213.3	57.8	40.2	17.6	559.5	714.1
25	**40G5**	18.8	179.5	90.0	320.9	437.6	147.8	120.0	50.4	1166.7	1365.0
25	**40G6**	613.9	1224.4	129.7	667.9	636.0	77.1	40.7	17.3	1568.7	3407.0
25	**40G7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	**41G6**	1.9	19.4	12.3	34.3	32.4	4.7	1.0	0.0	84.6	106.0
25	**41G7**	2.3	73.4	22.2	71.8	63.0	8.4	6.5	2.8	174.8	250.5
25	**Total**	**1094.0**	**5952.9**	**2770.0**	**9172.4**	**12268.4**	**4729.7**	**3829.2**	**1635.1**	**34404.7**	**41451.6**
26	**39G8**	0.1	30.0	17.7	72.3	92.6	38.8	28.1	18.9	268.4	298.4
26	**40G8**	0.9	52.2	40.4	85.1	110.4	18.1	17.4	6.3	277.7	330.8
26	**41G8**	0.0	55.3	8.2	71.0	81.6	18.8	3.7	3.7	187.0	242.3
26	**Total**	**1.0**	**137.5**	**66.3**	**228.4**	**284.6**	**75.7**	**49.2**	**28.9**	**733.1**	**871.6**
27	**42G7**	0.0	171.4	108.3	477.4	1949.9	646.3	228.6	44.7	3455.2	3626.6
28	**42G8**	0.0	60.2	17.0	55.2	116.7	29.8	7.6	15.7	241.9	302.1
24-28	**Total**	**10511.8**	**28131.3**	**7430.1**	**15341.4**	**18833.0**	**6917.0**	**7126.0**	**2577.0**	**58224.5**	**96867.6**

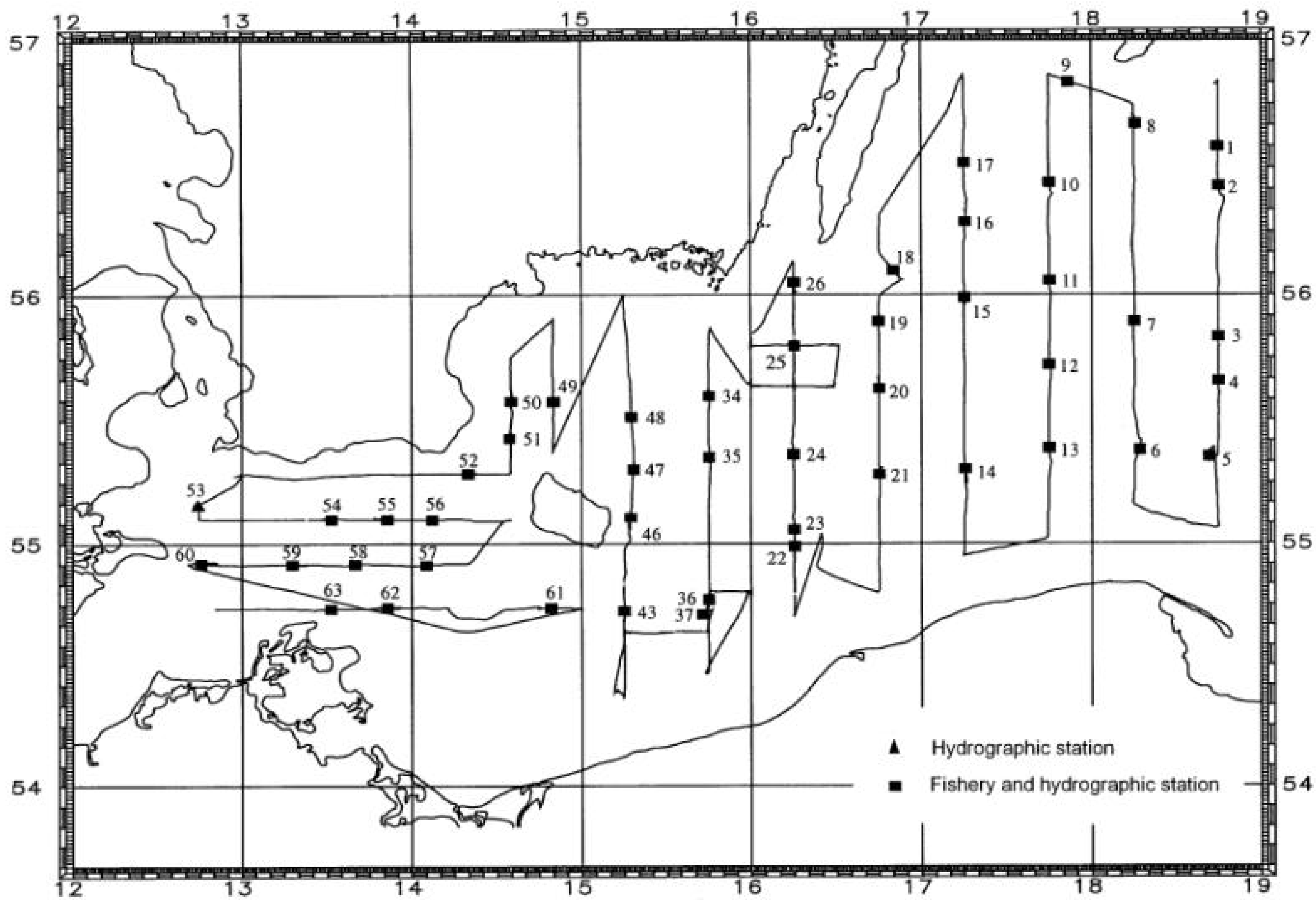

Figure 1 **Cruise track and trawl positions RV "Walther Herwig III" in May/June 1999**

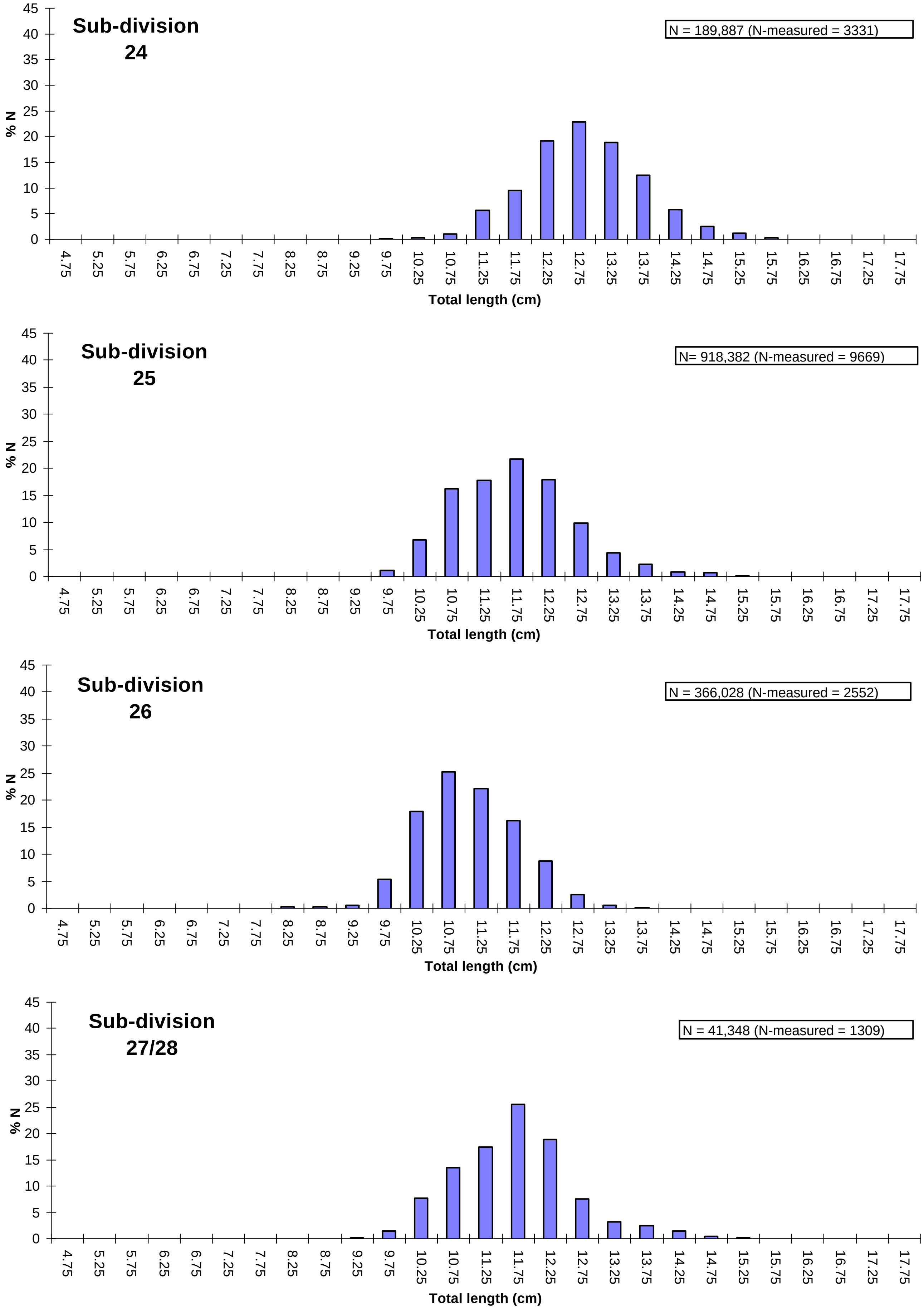

Figure 2 Length distribution of sprat in Sub-divisions 24, 25, 26 and 27/28 in May/June 1999

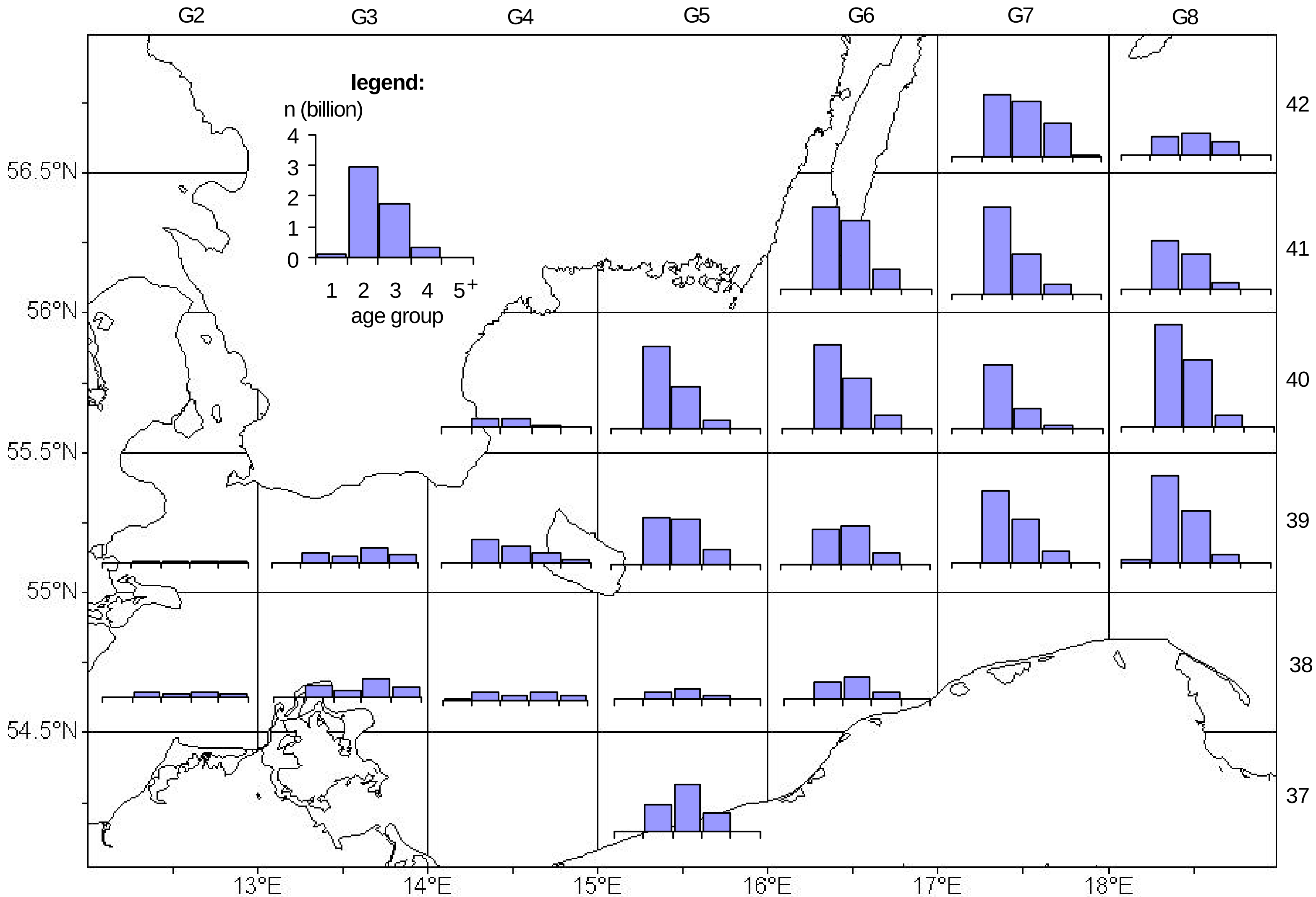

Figure 3 **Sprat number (billion) per age group and rectangle in May/June 1999**

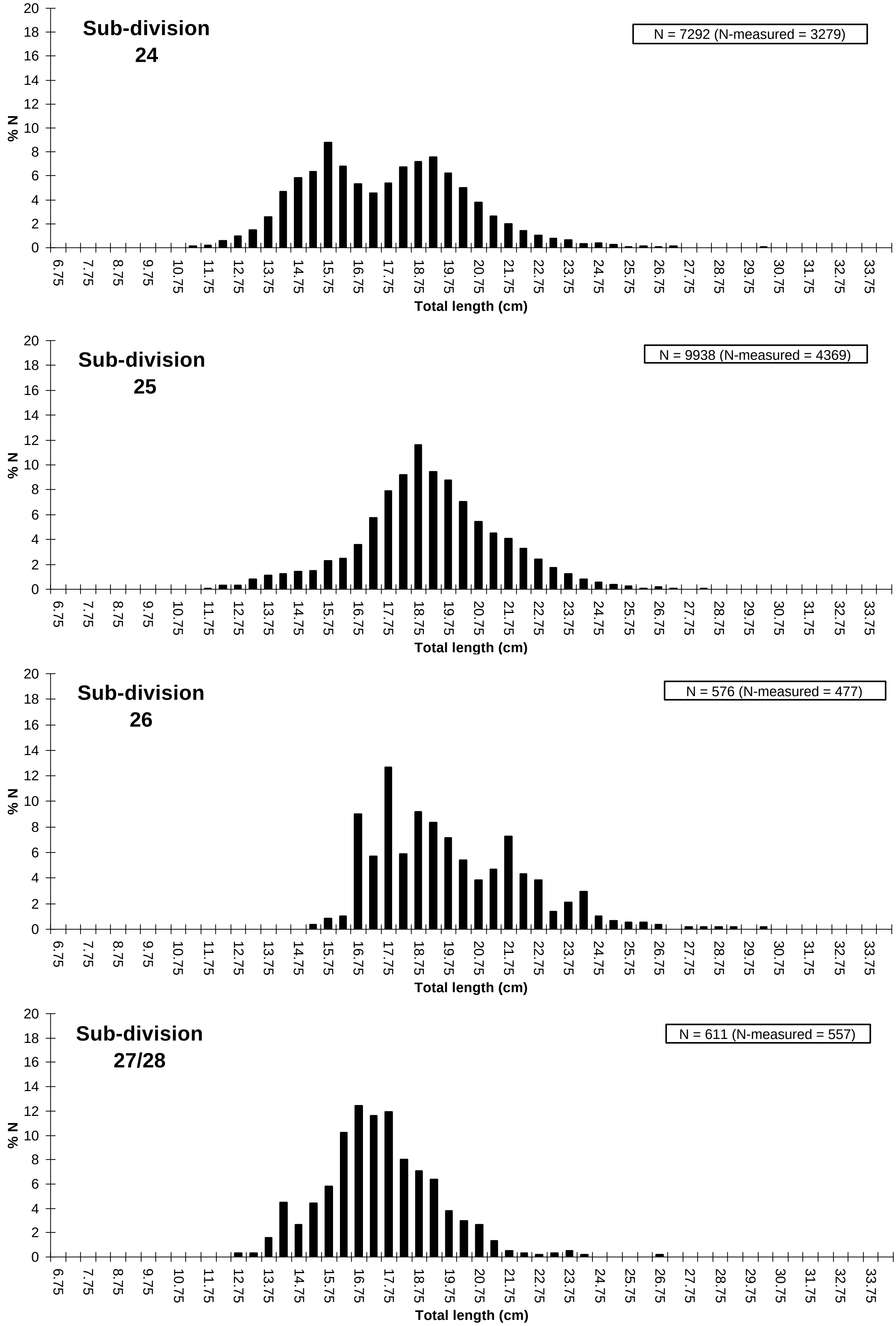

Figure 4 Length distribution of herring in Sub-divisions 24, 25, 26 and 27/28 in May/June 1999

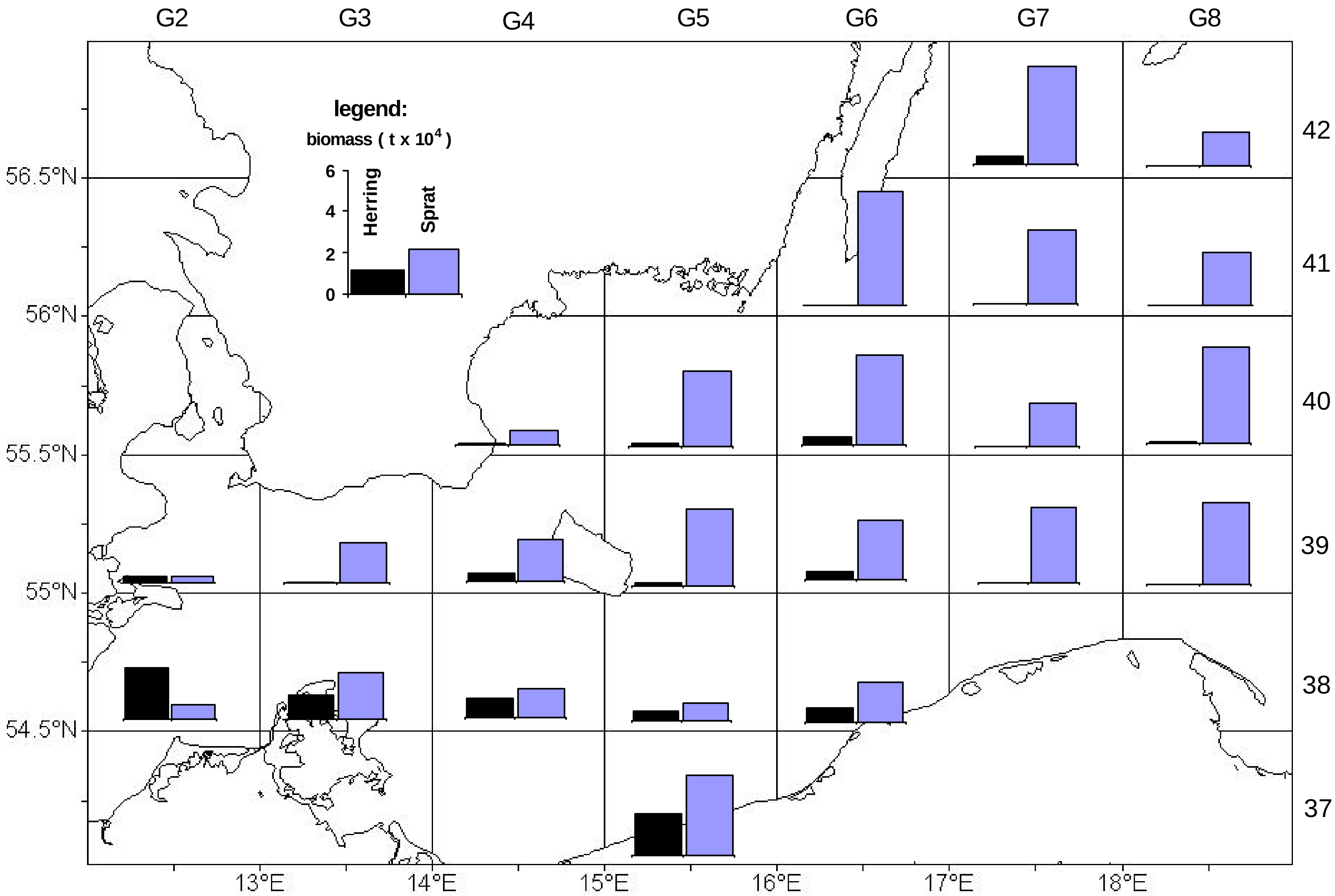

Figure 5 **Herring and sprat biomass per rectangle in the investigated area in May/June 1999**

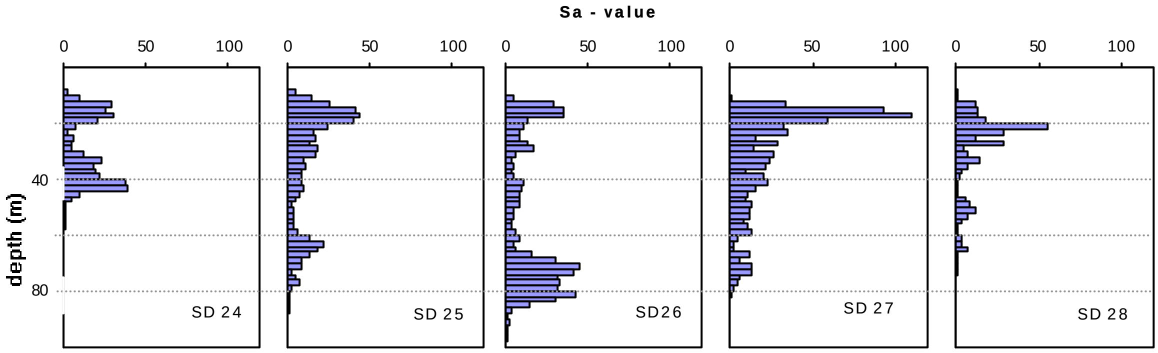

Figure 6 **Vertical distribution of the mean Sa-values per Sub-division in May/June 1999**

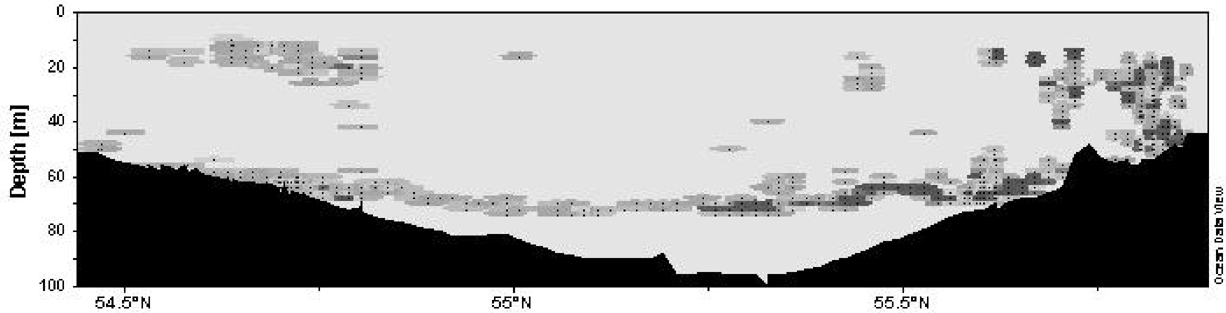

Figure 7 **Vertical distribution of Sprat on a transsect along 15.7°E from south to north across the Bornholm Basin in May/June 1999**

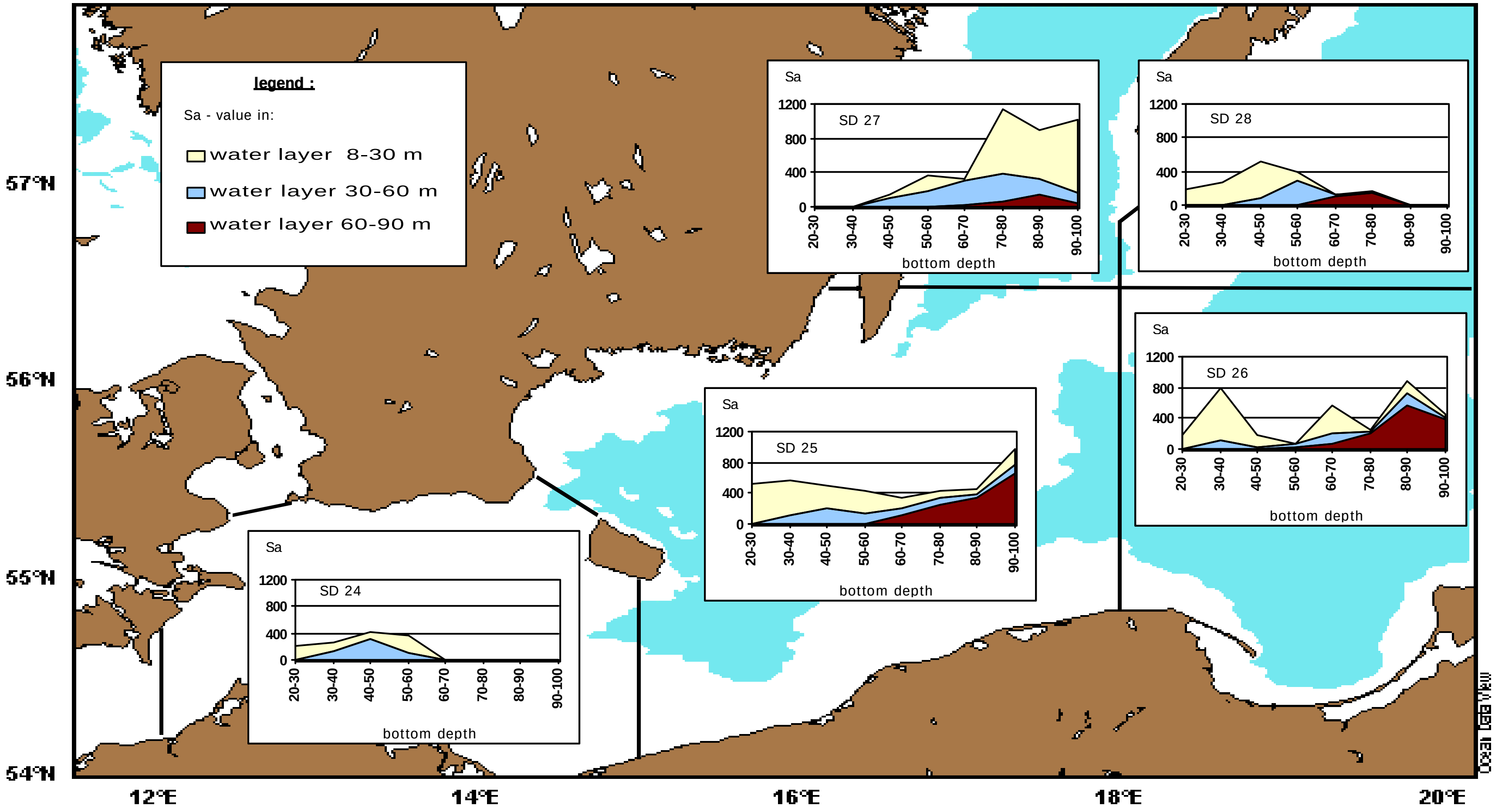

Figure 8 Mean Sa-values in the water layers 8 – 30m, >30 – 60m and > 60 – 90m in relation to bottom

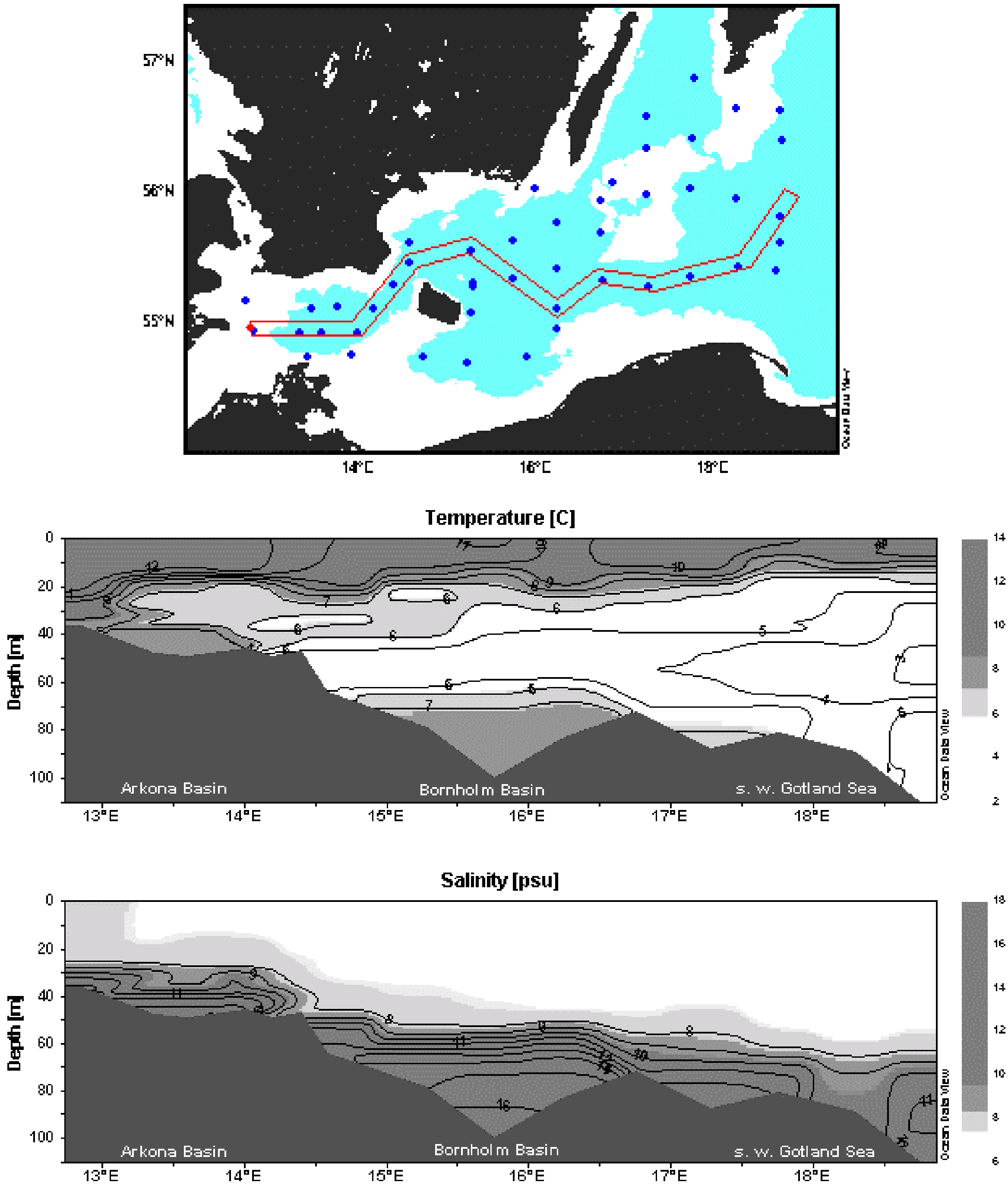

Figure 9 **Vertical contour plots of temperature and salinity from stations on a transect across the investigated area (RV „Walther Herwig III“ in May/June 1999).**

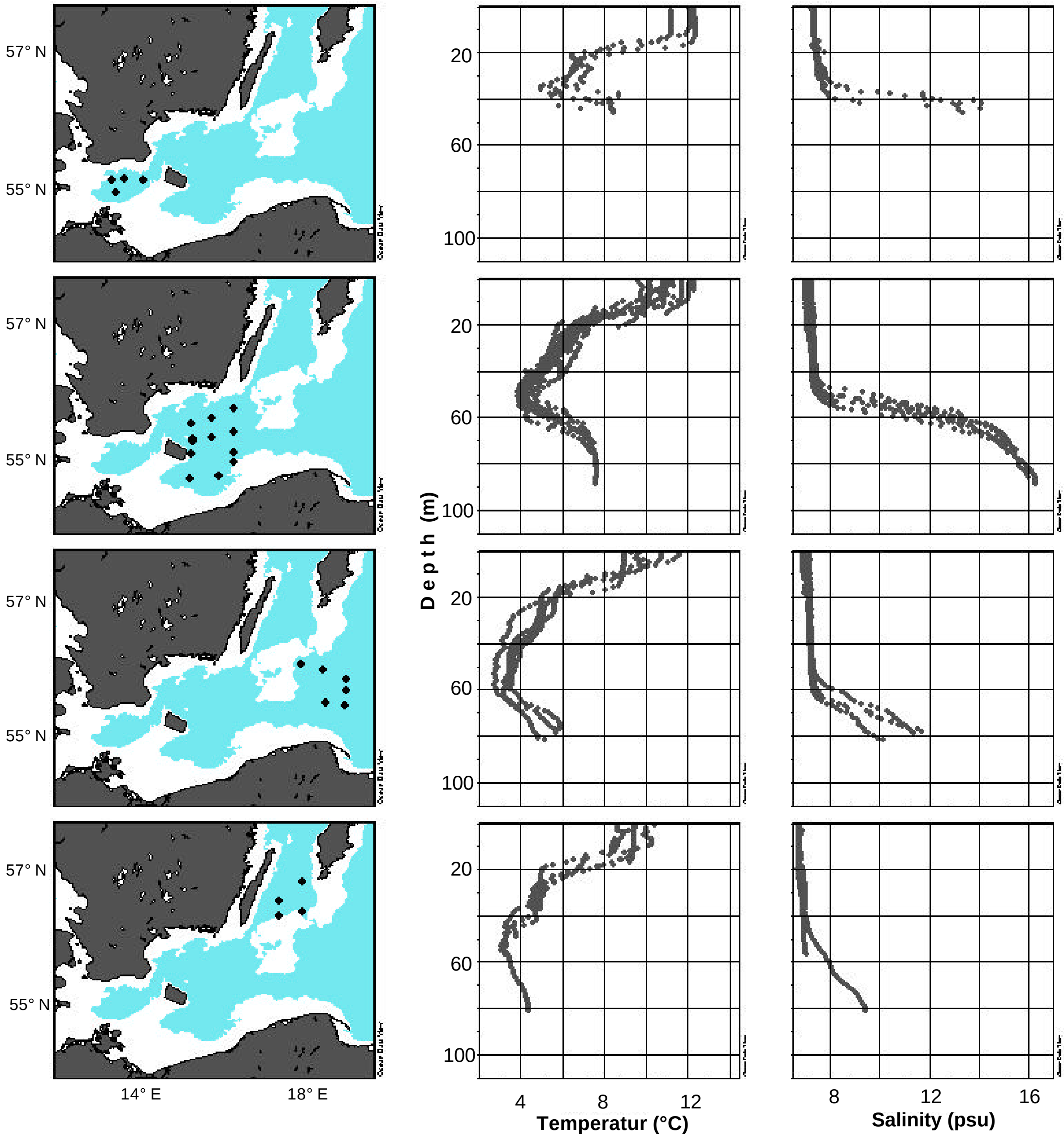

Figure 10 **Scatter plots of temperature and salinity on selected stations in the Arkona- and Bornholm Basin as well as in the s. w. Gotland and Öland Sea (RV „Walther Herwig III" in May/June 1999).**

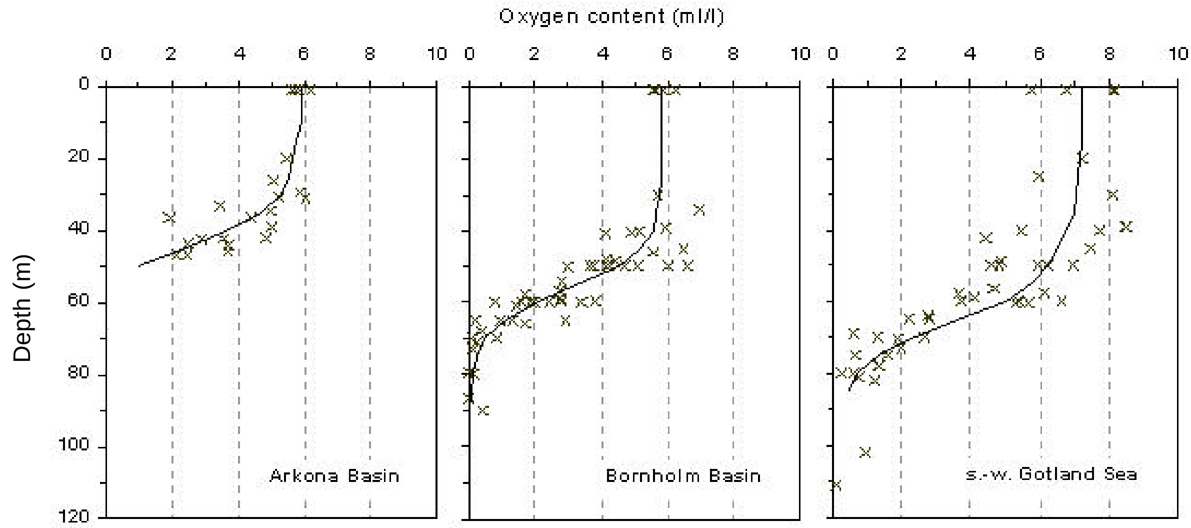

Figure 11 **Vertical distribution of oxygen content in the Arkona- and Bornholm Basin as well as in the s. w. Gotland Sea (RV „Walther Herwig III" in May/June 1999).**

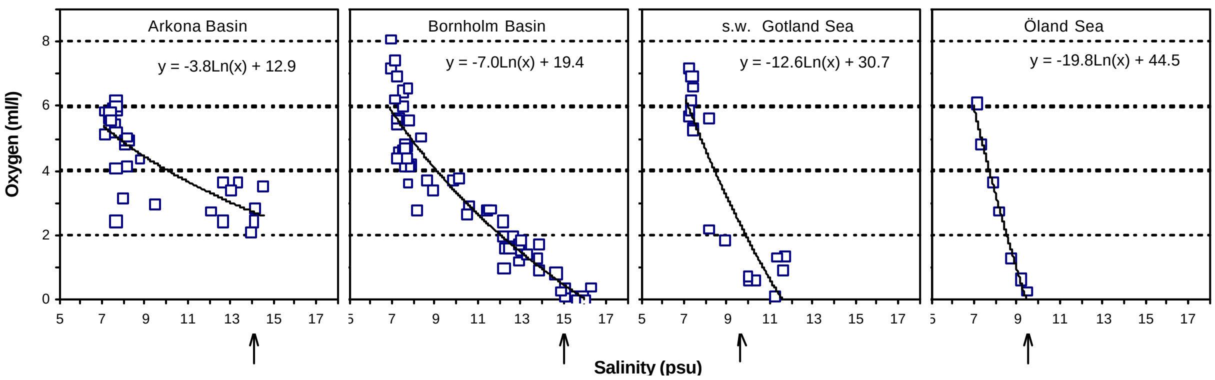

Figure 12 **The oxygen content vs. salinity in the Arkona- and Bornholm Basin as well as in the s. w. Gotland and Öland Sea (RV „Walther Herwig III" in May/June 1999). The border of sprat occurrence in relation to salinity is marked by arrows.**